Carruthers, J. B. (1) Prediction of Technical School Success.

1948

BOSTON UNIVERSITY

SCHOOL OF EDUCATION

Thesis

A PREDICTION OF TECHNICAL SCHOOL SUCCESS

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(A.B. Clark University 1938)

In partial fulfillment of the requirements for
the degree of Master of Education

1948

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CHAPTER I

The problem of selection of students with the best possible chance for success was one that arose when the author was personnel director at WXYZ Technical Institute. The principal of the school and the head of the admissions committee realized the need of research in this area. With their cooperation a tentative battery of paper and pencil tests was selected and administered to prospective students. The battery had to be chosen on an empirical basis as the available studies did not relate directly to technical institutes. This was somewhat surprising considering the fact that prediction of school success is one of the more common areas of educational research. The fact that technical institutes are a more recent arrival on the educational scene may be partly responsible. The other is that a majority of the schools are proprietary and thus have a different outlook from an endowed institution. As available studies were on such related fields as shop courses in high schools, engineering colleges, industry and defense and armed force training programs the tests had to be chosen as being most closely related to our problem. Even if studies had been found that were based on

technical institutes the problem would still have existed of validating them against the specific situation.

Separate test batteries were set up for the technical and the trade courses. Both included the Otis Quick-Scoring Mental Ability Test, the Revised Minnesota Paper Form Board, and the Bennett Test of Mechanical Comprehension. The technical battery included the Foust-Schorling Test of Functional Thinking in Mathematics and the Iowa Algebra Aptitude Test. The trade group received the Purdue Industrial Classification Test, the Otis Arithmetic Test and the Thurstone Vocational Guidance Test in Arithmetic. From here on in this thesis these tests will be referred to by the abbreviated titles commonly used in the field of guidance. For the full title, form, author and publisher the reader is directed to Appendix B.

The school offers technical courses in Machine Construotion and Tool Design, Steam and Diesel Engineering, Architectural Construction, Aircraft Maintenance Engineering, Electrical Construction, and Industrial Electronics. The trade level courses offered include Pattern-making and Machine Design, Machine Work and Tool Making, and Building Con-

struction. Henceforth these courses will be referred to by the first letters of the course title. The three trade courses include eight different subjects and the six technical courses include nineteen different subjects. Appendix C gives the breakdown of the subjects listed in the various courses. Only first year subjects are listed as the study is based on the first year marks. The major difference between the two courses is the absence of higher mathematics and the greater emphasis on shop work in the trade courses.

The problem then is whether it is possible to select successful students on the basis of a battery of paper and pencil tests. It may be further broken down into success in the school, success in one of the two types of courses, success in the separate courses, or success in the individual subject. At first glance it might seem that there is a certain amount of overlapping here. To some extent this may be true. The author felt that in a pilot study the greatest value could be achieved by investigating each of these areas to see which offered the best potentialities for further research. For example, if the skills needed (or the level of skill) varied from course to course or

from subject to subject then achievement in the larger groupings might mask the true picture. It would seem to be worth investigation for at the very least it would serve to show areas not productive for further study.

One hundred and seventy nine of the applicants tested were accepted as students and remained in school long enough so that marks were available as a criterion of school success. The author realizes that there has been a great deal of criticism of the conventional marking systems. Much of it is undoubtedly valid but even if a working substitute were available the problem here is not one of reform of the marking system but of prediction of success within that framework. As objective achievement tests do not exist in the subjects covered in a technical institute in most instances the only available criteria are the subject marks. Seeing that the factor of school success and therefore marks are largely distorted by the personal factor the probability exists that success in a job is also influenced by this same factor. If this premise were true then ability to get along in school would imply a somewhat similar ability at work. Whether this holds generally true or not the

problem is to find a better method of predicting success in this school within the present marking system. The elimination of those that fail would enable the students to save their time and the school to devote its energies to those with the best potentiality for success. This is certainly a worthwhile objective from both points of view.

Appendix D lists the details of the marking system used by the school. The method of weighting the subjects in relation to their importance for success in the course has certain commendable points. The weights given to the various subjects are listed in Appendix C. The danger of subjective empiricism is present due to the fact that faculty action was the basis for arriving at the weights to be given to a subject. The hours spent on a subject as well as its relative importance were taken into consideration. It might be that the differential between course and subject achievement might balance out due to the factor of weighting.

The problem is limited to one entering class. The study should be worth the time involved however as it should give some indication of the direction most promising for further research. No expectation is entertained that such a brief study could more than start on

the road to a solution to the problem as to whether it is possible to predict success in a technical institute on the basis of a battery of group tests.

CHAPTER II

PREVIOUS RELATED RESEARCH

The problem of school success has been a rather common one in the field of educational psychology. The available studies were in shop courses, trade high schools, college engineering, defense training courses, armed forces training courses, and industrial studies. Empirically we would expect a certain amount of similarity as on the surface the criterion appears to be similar in many instances.

This writer intends to show the previous correlations of both reliability and validity for the tests in the battery. This is not perhaps the most common method of handling the question of previous research. It seems to have certain advantages in this case as for one thing no previous study duplicated the present test battery. In a way it leaves little alternative except to report previous studies on the basis of what was uncovered in the literature on the individual tests.

The Otis Q-S, the Otis Arithmetic and the Thurstone Arithmetic were largely included in the battery because they had been previously used in the school and the admissions committee was familiar with them.

No previous studies had been made to try to validate these tests however. The other tests were chosen on the basis of what previous studies had shown and by inspection of the tests to see if they seemed to have elements that might be considered necessary to success in school. The tests will be taken up in the order in which they are listed in Appendix B.

The Otis Q-S has a reliability reported as ranging from .85 to .91 with the use of the Spearman-Brown formula.[1] The correlation with the Otis S-A higher form was .86.[2] The best validity correlations obtained were .69 with grades in a fabric inspection course and .60 in a material testing course in a defense training program.[3] While the other extreme showed a correlation as low as -.37 with a supervisor's rating on quantity of production and -.23 with the actual production.[4]

1. A. S. Otis. "Manual of Directions for Gamma Tests, Forms Am and Bm of Otis Quick-Scoring Mental Ability Tests," World Book Company, Yonkers-on-Hudson, New York, 1937

2. Ibid.

3. W. McGehee and D. J. Moffie. "Psychological Tests in the Selection of Enrollees in Engineering, Science, Management, Defense Training Courses," Journal of Applied Psychology, 26, 584-86

4. J. Tiffin and R. J. Greenly. "Employee Selection Tests for Electrical Fixture Assemblers and Radio Assemblers," Journal of Applied Psychology, 23, 240-63

The Minnesota Paper Form Board has an interform reliability of .85 and of .92 using the Spearman-Brown formula.[1] Other reliability studies showed .85,[2] .92,[3] .93 and .90.[4] In the area of validity, correlations from .43 to .18 with engineering students were found;[5] with judged trade ability of apprentices .58;[6] with defense courses on instructors ratings in aeronautical repair .03, aircraft engines .18 and aircraft electricity .22;[7] with mechanical drawing grades .49 and with descriptive geometry grades .32;[8] with the Otis

1. W. H. Quasha and R. Likert. "The Revised Minnesota Paper Form Board Test," Journal of Educational Psychology, (1937), 28, 197-204

2. W. H. Quasha and R. Likert. "Manual of Directions for the Revised Minnesota Paper Form Board Test," Psychological Corporation, New York, 1941

3. E. N. Brush, "Mechanical Ability as a Factor in Engineering Aptitude," Journal of Applied Psychology, (1941), 25, 300-12

4. O. M. Hall. "An Aid to the Selection of Pressman Apprentices," Personnel Journal, (1933), 9, 77-81

5. Brush, op. cit.

6. Hall, op. cit.

7. Jacobsen. "Evaluation of Certain Tests in Predicting Mechanical Learner Achievement," Educational and Psychological Measurements, (1943), 3, 3-21

8. W. H. Quasha and R. Likert. "The Revised Minnesota Paper Form Board Test," Journal of Educational Psychology, (1937), 28, 197-204

Mental Ability .53[1] and .40;[2] with percent efficiency of put-in-coil girl -.52, with average number of assemblies per hour of pull-socket assemblers .05, with percent efficiency of power sewing-machine operators .31 and .48, and with percent efficiency of merchandise packers .49;[3] with proficiency of inspector-packers .57;[4] and .14 with grades in architectural engineering and .35 with engineering drawing in defense courses.[5]

The Bennett Mechanical test shows reliabilities of .84 by the Spearman-Brown formula[6] and from .90 to .93 by the test-retest.[7] The validities found were .65 with grades in aircraft inspection, .35 with architectural

1. G. K. Bennett and R. M. Cruikshank. A Summary of Manual and Mechanical Ability Tests (Preliminary Form), Psychological Corporation, New York, 1942.

2. Quasha and Likert, op. cit.

3. W. H. Stead, C. L. Shartle, et al. Occupational Counseling Techniques, American Book Company, New York, 1940

4. E. E. Ghiselli. "Tests for the Selection of Inspector-Packers," Journal of Applied Psychology, (1942), 26, 468-76

5. McGehee and Moffie, op. cit.

6. G. K. Bennett. "Manual of Directions, Test of Mechanical Comprehension Form AA, " Psychological Corporation, New York, 1941

7. Bennett and Cruikshank, op. cit.

engineering and .16 with material testing;[1] .24 with instructors rating in mechanical ability;[2] with Co-operative Bhysics test .53 and with the Cooperative Algebra .17;[3] with the Otis S-A Mental Ability .45;[4] with the Moore Arithmetic Reasoning test .52 and with chemistry course grades .36;[5] with supervisers'rating in operation of machine tools .64;[6] with instructors' ratings in aircraft engines .11, aircraft electricity .41, and machine shop .35;[7] and with the Revised Minnesota Paper Form Board .59.[8]

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1. McGehee and Moffie, ~~o~~p. cit.

2. J. W. McDaniel and W. A. Reynolds. "Study and Use of Mechanical Aptitude Tests in the Selection of Trainees for Mechanical Occupations," Educational and Psychological Measurements, (1944), 4, 191-197

3. Bennett and Cruikshank, op. cit.

4. B. V. Moore. "Analysis of Results of Tests Administered to Men in Engineering Defense Training Courses," Journal of Applied Psychology, (1941), 25, 619-35

5. Bennett and Cruikshank, op. cit.

6. G. K. Bennett and R. A. Fear. "Mechanical Comprehension and Dexterity," Personnel Journal, (1943), 22, 12-17

7. Jacobsen, op. cit.

8. Bennett, op. cit.

The Foust-Schorling Mathematics test showed interform reliabilities ranging from .67 to .88 and from .82 to .88 using the Kuder-Richardson formula.[1] Correlations of .66 with the Terman-McNemar Test of Mental Ability and .53 with the Schorling-Clark-Potter 100 Arithmetic Problem Test were reported in the literature.[2]

The reliability reported on the Iowa Algebra test was .87 using the Kuder-Richardson formula.[3] Validities were reported that showed .66 with algebra grades, .76 with the California Research Algebra tests and .80 and .81 with two other algebra prognosis tests.[4]

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1. J. W. Foust and R. Schorling. "Manual of Directions for the Foust-Schorling Test of Functional Thinking in Mathematics," World Book Company, Yonkers-on-Hudson, New York, 1944

2. *Ibid.*

3. H. A. Greene and A. H. Piper. "Examiner's Manual for the Revised Edition of the Iowa Algebra Aptitude Test," Bureau of Educational Research and Service, State University of Iowa, Iowa City, 1942

4. *Ibid.*

The Purdue Industrial test showed reliabilities ranging from .73 to .94.[1] Critical ratios of 3.0 between the upper and lower twenty-five percents of the National Youth Administration industrial trainees and 4.6 for National Defense trainees were reported.[2]

No statistical results were discovered for either the Otis Arithmetic or the Thurstone Arithmetic. This writer is loath to report verbalizations.

The reader may find a comparison between these results and those obtained in the present study interesting.

1. C. H. Lawshe and A. C. Moutoux. "Preliminary Manual for the Purdue Industrial Training Classification Test," Science Research Associates, Chicago, 1942

2. Ibid.

CHAPTER III

THE PROCEDURE

Previous research in related areas would lead one to expect some relationship between test scores and school marks. The question was not whether a relationship existed but rather how strong it was. The bi-serial r for correlation between the test scores and the school marks was used because it was felt to be more important to predict the group into which the student fell than his exact individual position on a scale. The other factor that led to the adoption of the bi-serial r was that the school marks available were in letter grades only. While in theory the marks were a continuous series the net effect is of only seven categories (see Appendix D). The computation of the grade index (Appendix D) gives the surface appearance of a continuous series but as it is based on the letter grades this is an assumption rather than an actual occurrence. If the grade index were used for the courses then the subjects would have to be based on the letter grades only which would not give an accurate comparison between subject and course achievement which is one of the areas felt to need investigation in this

pilot study. When the above was added to the probability that it would be more valuable to the school in the selection of students to predict the more successful as opposed to the less successful, the bi-serial r was the final choice.

The formula used for the computation of the bi-serial r was $\frac{M_p - M_q}{\sigma} \cdot \frac{pq}{z}$ in which M_p equals the mean of the upper group, M_q equals the mean of the lower group, σ equals the standard deviation of the entire group, p equals the proportion of the whole group in category one, q equals the proportion of the whole group in category two ($p = 1-q$), and z equals the height of the ordinate in the normal curve dividing p from q.[1]

The next decision was where the division should be made to give the dichotomous classifications necessary for computation of the bi-serial r. The splits were made in all cases between the actual school grades. The reason why the lowest ten or twenty percent was not used as the criterion refers back to the fact that the letter grades are not usable as a continuous series

1. H. E. Garrett. Statistics in Psychology and Education, Third Edition, Longmans, Green and Company, New York, 1947, p. xii-350

for if a percentage comes in the middle of a grade no way exists of telling which individuals are actually higher or lower.

The question still remained as to where on the scale the divisions should be made. A few experimental correlations were run splitting the marks at all the grade divisions. On the basis of these trial runs the optimum cutting points were chosen for the experiment as a whole. Two division points seemed to offer about equal results and it was decided to use both throughout the study. These were a split between the marks of A, B+, B, and C+, and of C, P, and D; and between the marks of A, B+, and B, and of C+, C, P, and D. The possibility exists that some worthwhile relationships may have been missed by not running correlations at every possible dividing point. As sixteen correlations were run using a variety of division points and as the two listed above were the only ones showing enough promise there seems to be reasonable basis for limiting this study to these two different dichotomies.

The obtained bi-serial r's were tested against the null hypothesis by the formula $t = \frac{r_{bis}\sqrt{N-2}}{\sqrt{1-r^2}}$.[1]

1. <u>Ibid.</u>, p. 298

In actual use Garrett's table #49 is entered with N-2 degrees of freedom and entry shown is the size correlation that must be found before we can say that the obtained correlation is not due to errors of sampling. To put it another way, if the obtained correlation is larger than the table entry then we may be confident at the .01 or .05 level that the true correlation is not zero. The use of the null hypothesis as a test for the significance of correlation is most useful when the number is small as it is there that the $PE_{r\ bis}$ is apt to be most misleading. The reason Garrett gives for this is that the formula of $PE_{r\ bis}$ is based on the use of the population r_{bis} and one actually used in the computation is the sample r_{bis} so that at best all we get is an approximation of the error of the obtained correlation. The other factor is that the sampling distribution of r_{bis} is not normal except when the population r_{bis} is .00 and N is large.[1] As only a few of the correlations in this study had N's larger than 100 and as many had less than 50, the use of the null hypothesis seemed to offer a more valid criterion for judging the significance of the obtained correlations.

1. *Ibid.*, p. 297-302

In the tables in Chapter IV the significance of the bi-serial correlations are shown as measured against both the .01 and the .05 level. This writer feels that the .01 level is the better criterion but as this is more or less of a pilot study it was thought that the indication of those reaching the .05 level might be of assistance in indicating potentialities for further research.

The study is based on the first year marks of the one hundred and seventy-nine students. The marks of those who dropped out of school for any reason including failure were included using the marks obtained as though they had completed the year. This was done so that their influence on the total result would not be lost.

The arbitrary number of twenty-nine was chosen as the smallest group on which to run a correlation. It was cut here because of the class sizes. Also, it was felt that any groups smaller than this had little to offer. The σ on the groups of less than 100 was actually s as N-1 was used in its computation. In all cases the raw test scores were used rather than intelligence quotients, standard scores or percentiles.

The intercorrelations between the various tests in the battery shown in Table X were computed by the Pearson product moment formula. As the test scores were both actually continuous series this seemed the most suitable and certainly the one most commonly used in research in this area. Here again the obtained r was tested against the null hypothesis. In some instances where the optimal finding would be a low correlation the fact that the null hypothesis was retained is the ideal finding. On the assumption that the true or population r was zero then if the obtained correlation can be attributed to sampling errors then we could assume pending further study that the probability existed that we were actually testing separate factors.

CHAPTER IV

ANALYSIS OF THE DATA OBTAINED

In the attempts to analyze the data garnered by the methods indicated in the preceding chapter the question became one of whether it would be more advantageous to arrange the tables to show all the correlations with the various criteria obtained for each test in the battery, or whether the tables should show the correlations obtained for each criterion with the various tests. As each offered advantages not possible for the other the final decision was to give the complete data for the first and for the second to show those that were correlated with enough different tests so that some comparisons would be inherent in the tables. A glance at Table I compared to Table VI should make clear the difference in tabulation involved.

Table I (page) shows the bi-serial correlations between the Otis Q-S Mental Ability Test and the various criteria. Of forty-four correlations (twenty-two criterion run in each of the dichotomies used) ten are significant at the .01 level and seven at the .05 level. The correlations significant at the .01 level show four in the .20 to .30 bracket, four in the .30

TABLE I

OTIS QUICK-SCORING MENTAL ABILITY TEST

Criteria	Number	A,B+,B,C+ vs. C,P,D	A,B+,B vs. C+,C,P,D
Total grades (all courses)	179	.23 **	.15 #
Technical courses	133	.37 **	.25 **
Technical Math.	133	.25 **	.28 **
M.C.,S.&D.E.,& E.C. Courses	61	.48 **	.17
A.C. course	31	.28	.06
Technical English	91	.38 **	.46 **
Tech. Patternmaking	74	.06	.03
Tech. Welding	77	.06	.09
Tech. Electricity	86	.24 #	.16
Tech. Elec. Motor Lab.	86	.16	.24 #
Tech. Machine Work	74	.03	-.06
Tech. Arch. Drawing	31	.26	.23
Tech. Bldg. Methods	31	.16	.02
Tech. Carpentry	31	.15	.06
Tech. Applied Physics (AC)	31	.17	.03
Tech. Bldg. Mat. Lab.	31	.07	.15
Tech. Mech. Drawing	102	.36 **	.10
Tech. Applied Physics	86	.19	.32
Trade courses	46	.35 #	.35 #
Trade Physics	46	.33 #	.26
Trade Mech. Draw.	30	-.04	.19
Trade Math.	46	-.09	.33 #

** Significant at .01 level tested against the null hypothesis

Significant at .05 level tested against the null hypothesis

to .40, and two in the .40 to .50 while at the .05 level one is in the .10 to .20, two in the .20 to .30, and four in the .30 to .40 grouping. The evaluation rather common in the interpretation of the significance of r's is to call .00 to .20 indifferent, .20 to .40 as present but low, .40 to .70 as marked or substantial, and .70 to 1.00 as very significant.[1, 2, 3, 4] Only two correlations at the .01 level reach the arbitrary level of "marked" (.40 to .70) and none of those at the .05 level. These are one of .48** with MC, SDE, and EC course grades and .46** with technical English grades. The general trend throughout this table is for a slightly higher correlation to be shown for those subjects that by inspection seem to have more academic elements. Correlations of .03 and -.06 with technical machine work, .06 and .03 with technical patternmaking, and .06 and .09 with technical welding

1. W. V. Bingham. Aptitudes and Aptitude Testing, Harper and Brothers, New York, 1937

2. M. E. Broom. Educational Statistics, American Book Company, New York, 1936

3. Garrett, op. cit.

4. H. O. Rugg. Statistical Methods Applied to Education, Houghton Mifflin Company, Boston, 1917

TABLE II

REVISED MINNESOTA PAPER FORM BOARD

Criteria	Number	A,B+,B,C+ vs. C,P,D	A,B+,B vs. C+,C,P,D
Total grades (all courses)	179	.27 **	.22 **
Technical courses	133	.28 **	.19 #
M.C.,S.&D.E.,& E.C. Courses	61	.39 **	.05
A.C. course	31	.38 #	.01
Tech. English	90	-.13	.04
Tech. Patternmaking	74	.48 **	.28 #
Tech. Welding	77	.19	.20
Tech. Mach. Work	74	.04	.21
Tech. Electricity	86	.38 **	.31 **
Tech. Elec. Motor Lab.	86	.15	.21 #
Tech. Arch. Drawing	31	.00	.05
Tech. Bldg. Methods	31	-.21	.25
Tech. Carpentry	31	.52 **	.48 **
Tech. Applied AC Physics	31	.23	-.06
Tech. Bldg. Mat. Lab.	31	.01	-.12
Tech. Mech. Drawing	102	.27 **	.31 **
Tech. Applied Physics	86	-.03	.21 #
Tech. Mathematics	133	-.02	.01
Trade courses	46	.39 **	.35 #
Trade Physics	46	.37 #	.15
Trade Mech. Draw.	30	-.10	-.02
Trade Math.	46	.30 #	.50 **

** Significant at .01 level

Significant at .05 level

as opposed to .36** and .10 with technical mechanical drawing, .19 and .32** with technical applied physics and .25** and .28** with technical mathematics are examples of the trend just mentioned. All the correlations reaching a level of significance are in the more academic subjects with the single exception of technical electrical motor laboratory which shows .16 and .24#.

The bi-serial correlations between the Minnesota Paper Form Board and the school criteria are in Table II (page). Here also forty-four correlations were run. In this instance there were thirteen correlations significant at the .01 level and eight at the .05 level. At the .01 level four were in the .20 to .30 group, five in the .30 to .40, three in the .40 to .50, and one in the .50 to .60. While of those reaching the .05 level one was in the .10 to .20 group, four in the .20 to .30 and three in the .30 to .40 classification. Using the arbitrary level of .40 or above we find technical patternmaking with .48** and .28#, technical carpentry with .52** and .48**, and trade mathematics with .30# and .50**. Technical mathematics shows correlations of only -.02 and .01 which compared to the trade mathematics above does not seem quite logical.

A possible clue could be that the trade mathematics is based to a larger extent than is the technical on practical problems. This is not conclusive but is at least suggestive. On the other hand, if we compare those on technical patternmaking mentioned above with those of .04 and .21 in technical machine work no logical answer is immediately apparent for the use of wood in one and metal in the other hardly seems the answer and the machines involved are basically similar except for the material they work on. The course description offers nothing that on the surface is a reasonable clue. Technical carpentry consists of a different group of students and involves less complicated woodworking and yet the correlations are .52** and .48**. Technical mechanical drawing, which empirically one would expect to be high, shows only .27** and .31**, trade mechanical drawing shows much less -.10 and -.02, and technical architectural drawing is .00 and .05. No answer is apparent from the available evidence. More experimentation is obviously needed before an answer can be given. It might be that this test is not an all-round measure of spatial relations but present evidence is not sufficient to prove or disprove this.

TABLE III

BENNETT MECHANICAL COMPREHENSION TEST

Criteria	Number	A,B/,B,C/ vs. C,P,D	A,B/,B vs. C/,C,P,D
Total grades (all courses)	138	.02	.16
Tech. Courses	99	.15	.38 **
M.C.,S.&D.E.,& E.C. Courses	47	.24	.50 **
Tech. English	68	-.13	-.10
Tech. Patternmaking	58	.38 **	.64 **
Tech. Welding	60	.10	.28 #
Tech. Elec. Motor Lab.	64	.18	.27 #
Tech. Electricity	64	.25 #	.46 **
Tech. Mach. Work	58	.10	.00
Tech. Mech. Drawing	77	.32 **	.23 #
Tech. Applied Physics	64	.18	.28 #
Tech. Mathematics	99	.21 #	.19
Trade courses	38	-.04	.02
Trade Physics	38	-.22	-.27
Trade Mathematics	38	-.45 **	-.22

** Significant at .01 level

Significant at .05 level

The correlations involving the Bennett Mechanical Comprehension are to be found in Table III on page . Here thirty correlations were run on the fifteen groups that were larger than the chosen minimum. Seven were significant at the one percent level and six at the five percent level. At the .01 level three were in the .30 to .40, two in the .40 to .50, one in the .60 to .70 and one in the -.40 to -.50 range. All six of those at the .05 level were in the .20 to .30 grouping. Here as in the Paper Form Board we find no pattern such as the Otis showed in the ability to discriminate between the academic and the shop subjects. Evidently this pilot study has only been an entering wedge into a wide problem. Further proof of the above statement could be implicit in the difference between technical applied physics of .18 and .28# and trade applied physics of -.22 and .27. The possibility exists that the differences might be dependent on the differences between the present students more than on any other factor. Only further experimentation could answer this.

The results of the Foust-Schorling show twenty-two correlations with the eleven criteria that were above the size selected as a minimum (Table IV, page).

TABLE IV

FOUST-SCHORLING TEST OF FUNCTIONAL THINKING IN MATHEMATICS

Criteria	Number	A,B+,B,C+ vs C,P,D,	A,B+,B vs. C+,C,P,D
Tech. Courses	107	.46 **	.41 **
MC,S&DE,&EC Courses	50	.61 **	.38 **
Tech. English	71	.11	.08
Tech. Patternmaking	59	-.12	-.14
Tech. Welding	63	.07	.25 #
Tech. Mach. Work	61	.00	-.19
Tech. Elec. Motor Lab.	72	.08	.23
Tech. Electricity	72	.30 #	.50 **
Tech. Mech. Drawing	85	.44 **	.32 **
Tech. Appld. Physics	72	.39 **	.42 **
Tech. Math.	107	.22 #	.43 **

IOWA ALGEBRA PROGNOSIS TEST

Criteria	Number	A,B+,B,C+ vs. C,P,D,	A,B+,B vs. C+,C,P,D
Tech. Courses	95	.42 **	.32 **
MC,S&DE,&EC Courses	46	.53 **	.40 **
Tech. English	64	.17	-.01
Tech. Patternmaking	56	-.17	-.04
Tech. Welding	59	-.10	.11
Tech. Mach. Work	57	-.11	-.16
Tech. Elec. Motor Lab.	63	.18	.15
Tech. Electricity	63	.29 #	.54 **
Tech. Mech. Draw.	76	.36 **	.23 #
Tech. Appld. Physics	63	.45 **	.46 **
Tech. Math.	95	.36 **	.44 **

** Significant at .01 level # Significant at .05 level

Of these ten were significant at the one percent level and three at the five percent level. Those at the .01 level show three in the .30 to .40 range, six in the .40 to .50, and one in the .60 to .70 while all three at the .05 level are in the .20 to .30 grouping. Here again the pattern seems to be that the significant and the higher correlations are in the subjects requiring academic ability with the exception of technical English of .11 and .08. The term academic as used here has mainly the implication that it is the opposite of shop work, manual ability, and so forth, and is not intended to carry any implication of liberal arts or related. Those having the higher correlations are technical electricity .30# and .50**, technical mechanical drawing .44** and .32**, technical applied physics .39** and .42**, technical mathematics .22# and .43**, total technical courses .46** and .41**, and MC, SDE, and EC courses .61** and .38**.

The Iowa Algebra results are also in Table IV on page . For the eleven criteria twenty-two correlations were run of which ten were significant at the one percent level and two at the five percent level. On the .01 level three were in the .30 to .40, five in the .40 to .50, and two in the .50 to .60 grouping while both

of those at the .05 level were in the .20 to .30 range. Here as in the Foust-Schorling, and in a lesser extent as far as the size of the obtained bi-serial r's is concerned, the Otis Q-S, the pattern seems to show more correlation with the subjects that empirically at least require more academic or book ability. The examples are technical electricity .29# and .54**, technical mechanical drawing .36** and .23#, technical applied physics .45** and .46**, and technical mathematics .36** and .44**. The total technical courses show .42** and .32** and the MC, SDE, and ED courses .53** and .40** which possibly indicates that the weighting involved in the total grade index (see Appendix C and D) gives more weight to academic subjects than to shop. although this is not inherent in the present data.

The Purdue Industrial Test, the Thurstone Arithmetic test, and the Otis Arithmetic test are all in Table V on page . These tests were administered to those in the trade courses and very few of the groups were large enough to meet the arbitrary minimum for size of groups on which correlations were run.

The Purdue Industrial test shows six correlations, two significant at the one percent level and two at the five percent level. These are all trade courses .35#

of those at the .06 level were in the .20 to .30 range. Here as in the Foust-Schorling, and in a lesser extent as far as the size of the obtained bi-serial r's is concerned, the Otis Q-S, the pattern seems to show more correlation with the subjects that empirically at least require more academic or book ability. The examples are technical electricity .29% and .54**, technical mechanical drawing .36** and .23%, technical applied physics .45** and .46**, and technical mathematics .36** and .44**. The total technical courses show .42** and .32** and the MC, SUS, and ED courses .53** and .40** which possibly indicates that the weighting involved in the total grade index (see Appendix C and D) gives more weight to academic subjects than to shop, although this is not inherent in the present data.

The Purdue Industrial Test, the Thurstone Arithmetic test, and the Otis Arithmetic test are all in Table V on page . These tests were administered to those in the trade courses and very few of the groups were large enough to meet the arbitrary minimum for size of groups on which correlations were run.

The Purdue Industrial test shows six correlations, two significant at the one percent level and two at the five percent level. These are all trade courses .35%

TABLE V

PURDUE INDUSTRIAL CLASSIFICATION TEST

Criteria	Number	A,B+,B,C+ vs. C,P,D	A,B+,B vs. C+,C,P,D
Trade Courses	36	.35 #	.57 **
Trade Physics	36	.35 #	.46 **
Trade Mathematics	36	.29	-.01

THURSTONE VOCATIONAL GUIDANCE TEST IN ARITHMETIC

Criteria	Number	A,B+,B,C+ vs. C,P,D	A,B+,B vs. C+,C,P,D
Trade Courses	36	.51 **	.65 **
Trade Physics	36	.48 **	.52 **
Trade Mathematics	36	.20	.00

OTIS ARITHMETIC TEST

Criteria	Number	A,B+,B,C+ vs. C,P,D	A,B+,B vs. C+,C,P,D
Total Courses	66	.19	.15
Tech. Courses	37	.23	.18
Tech. Mathematics	37	.39 #	.31
Trade Courses	29	.35	.32
Trade Physics	29	.20	.18
Trade Mathematics	29	.34	.36

** Significant at .01 level

Significant at .05 level

and .57** and trade physics .35# and .46**. Trade mathematics is .29 and -.01 which is not what one might have expected. Why the correlation with the physics is higher than with the mathematics is something that will need more study before even the start of an answer will appear.

The Thurstone Arithmetic test also has six correlations run, four of which are significant at the one percent level and none at the five percent. Of these one is in the .40 to .50 range, two in the .50 to .60, and one in the .60 to .70. Here as in the Purdue Industrial test we find high correlation with two of the criteria, all trade courses .51** and .65** and trade physics .48** and .52** while the third which on the surface would seem more closely related to the test (trade mathematics) shows only .20 and .00. The available data does not give any obvious clue to the answer although the size of the groups makes further research almost essential before any conclusions are attempted.

The Otis Arithmetic test on which twelve correlations were run shows only one that is significant and that only at the five percent level. This is in the .30 to .40 grouping. If the numbers involved had been somewhat larger the possibility exists that significant

correlations might have been shown as trade mathematics with an N of 29 was .34 and .36. The only one reaching the present test of significance was in technical mathematics with .39# and .31.

In looking back over the ability to predict from a test the achievement in the school, in the course or in the various subjects, there is a great range for any given test as in the areas showing some, little, or no correlation. Tables VI through IX on pages , , , and show the correlations listed by each criterion for the various tests. If in Table VI we look at the tests that predict in all courses, technical courses, and MC, SDE, and EC courses we find a general pattern that the correlation increases as we go from the more general all courses to the more specific (in terms of subjects included in the curriculum) of MC, SDE, and EC courses. The examples of this would be the Otis Q-S of .23** and .15# in all courses, .37** and .25** in technical courses, and .48** and .17 in MC, SDE, and EC courses; the Minnesota Paper Form Board of .27** and .22** in all courses, .28** and .19# in technical courses, and .39** and .05 in MC, SDE, and EC courses; and the Bennett Mechanical of .02 and .16 in all courses, .15 and .38** in technical courses,

TABLE VI

Test	Number	A through C+ vs. C through D	A through B vs. C+ through D
		ALL COURSES	
Otis Q-S	179	.23 **	.15 #
Minn. P.F.B.	179	.27 **	.22 **
Bennett Mech.	138	.02	.16
Otis Arith.	66	.19	.15
		TECHNICAL COURSES	
Otis Q-S	133	.37 **	.25 **
Minn. P.F.B.	133	.28 **	.19 #
Bennett Mech.	99	.15	.38 **
Foust-Schorling	107	.46 **	.41 **
Iowa Algebra	95	.42 **	.32 **
Otis Arith.	37	.23	.18
		MC, S&DE, & EC COURSES	
Otis Q-S	61	.48 **	.17
Minn. P.F.B.	61	.39 **	.05
Bennett Mech.	47	.24	.50 **
Foust-Schorling	50	.61 **	.38 **
Iowa Algebra	46	.53 **	.40 **
		TECHNICAL MATHEMATICS	
Otis Q-S	133	.25 **	.28 **
Minn. P.F.B.	133	-.02	.01
Bennett Mech.	99	.21 #	.19
Foust-Schorling	107	.22 #	.43 **
Iowa Algebra	95	.36 **	.44 **
Otis Arith.	37	.39 #	.31

** Significant at .01 level

Significant at .05 level

TABLE VII

Test	Number	A through C≠ vs. C through D	A through B vs. C≠ through D
		TECHNICAL MECHANICAL DRAWING	
Otis Q-S	102	.36 **	.10
Minn. P.F.B.	102	.27 **	.31 **
Bennett Mech.	77	.32 **	.23 **
Foust-Schorling	85	.44 **	.32 **
Iowa Algebra	76	.36 **	.23 #
		TECHNICAL APPLIED PHYSICS	
Otis Q-S	86	.19	.32 **
Minn. P.F.B.	86	-.03	.21 #
Bennett Mech.	64	.18	.28 #
Foust-Schorling	72	.39 **	.42 **
Iowa Algebra	63	.45 **	.46 **
		TECHNICAL ELECTRICITY	
Otis Q-S	86	.24 #	.16
Minn. P.F.B.	86	.38 **	.31 **
Bennett Mech.	64	.25 #	.46 **
Foust-Schorling	72	.30 #	.50 **
Iowa Algebra	63	.29 #	.54 **
		TECHNICAL ELECTRICAL MOTOR LAB.	
Otis Q-S	86	.16	.24 #
Minn. P.F.B.	86	.15	.21 #
Bennett Mech.	64	.18	.27 #
Foust-Schorling	72	.08	.23
Iowa Algebra	63	.18	.15

** Significant at .01 level

Significant at .05 level

and .24 and .50** in MC, SDE, and EC courses. The Foust-Schorling differentiated between technical courses .46** and .41** and the MC, SDE, and EC courses .61** and .38**; as did the Iowa Algebra with .42** and .32** in technical courses as opposed to .53** and .40** in MC, SDE, and EC courses.

When we get into the prediction in the individual subject area we see that in technical mathematics (Table VI) the Foust-Schorling with .22# and .43** and the Iowa Algebra with .36** and .44** are the best with the Otis Q-S of .25** and .28** a poor second. Neither the Minnesota nor the Bennett are of much significance in this subject.

Technical mechanical drawing and technical electricity (Table VII) show the most consistently significant correlations of any criterion, although to be sure most of them are below the level that could be termed marked correlation. Those above the level of .40 are .44** and.32** between Foust-Schorling and technical mechanical drawing, .30# and .50** between Foust-Schorling and technical electricity, and .29# and .54** between Iowa Algebra and technical electricity. Technical applied physics (Table VII) shows .39** and .42** with the Foust-Schorling and .45** and .46** with the

TABLE VIII

Test	Number	A through C/ vs. C through D	A through B vs. C/ through D
TECHNICAL MACHINE WORK			
Otis Q-S	74	.03	-.06
Minn. P.F.B.	74	.04	.21
Bennett Mech.	58	.10	.00
Foust-Schorling	61	.00	-.19
Iowa Algebra	57	-.11	-.16
TECHNICAL PATTERNMAKING			
Otis Q-S	74	.06	.03
Minn. P.F.B.	74	.48 **	.28 #
Bennett Mech.	58	.38 **	.64 **
Foust-Schorling	59	-.12	-.14
Iowa Algebra	56	-.17	-.04
TECHNICAL WELDING			
Otis Q-S	77	.06	.09
Minn. P.F.B.	77	.19	.20
Bennett Mech.	60	.10	.28 #
Foust-Schorling	63	.07	.25 #
Iowa Algebra	59	-.10	.11
TECHNICAL ENGLISH			
Otis Q-S	91	.38 **	.46 **
Minn. P.F.B.	90	-.13	.04
Bennett Mech.	68	-.13	-.10
Foust-Schorling	71	.11	.08
Iowa Algebra	64	.17	-.01

** Significant at .01 level

Significant at .05 level

Iowa Algebra test.

With exceptions the general pattern in the individual technical subjects is higher correlation in those which seem to have more academic factors included (Table VI through VIII). Technical English shows only the Otis Q-S .38** and .46** as significant which would seem to indicate that the test battery was aimed in general at a technical trade curriculum rather than at an academic curriculum. While in the technical electrical motor laboratory, technical machine work, technical patternmaking and technical welding the only tests significant at the one percent level are the Minnesota .48** and .28# and the Bennett .38** and .64** with the technical patternmaking. Pending further studies the expected result would seem to be that different tests were needed to predict in the laboratory as opposed to the classroom subjects. Whether this would hold up under further research could only be answered in the future.

In Table IX the results of the various criteria in the trade courses and subjects are indicated. The general patterning of test prediction in trade courses is not too dissimilar to that in technical courses as the mathematics tests give better results than the

TABLE IX

Test	Number	A through C+ vs. C through D	A through B vs. C+ through D
		TRADE COURSES	
Otis Q-S	46	.35 #	.35 #
Minn. P.F.B.	46	.39 **	.35 #
Bennett Mech.	38	-.04	.02
Purdue Indust.	36	.35 #	.57 **
Otis Arith.	29	.35	.32
Thurstone Arith.	36	.51 **	.65 **
		TRADE MATHEMATICS	
Otis Q-S	46	-.09	.33 #
Minn. P.F.B.	46	.30 #	.50 **
Bennett Mech.	38	-.45 **	-.22
Purdue Indust.	36	.29	-.01
Otis Arith.	29	.34	.36
Thurstone Arith.	36	.20	.00
		TRADE MECHANICAL DRAWING	
Otis Q-S	30	-.04	.19
Minn. P.F.B.	30	-.10	-.02
		TRADE APPLIED PHYSICS	
Otis Q-S	46	.33 #	.26
Minn. P.F.B.	46	.37 #	.15
Bennett Mech.	38	-.22	-.27
Purdue Indust.	36	.35 #	.46 **
Otis Arith.	29	.20	.18
Thurstone Arith.	36	.48 **	.52 **

** Significant at .01 level

Significant at .05 level

others. The Purdue shows .35# and .57**, the Thurstone Arithmetic .51** and .65** while the Otis Q-S shows .35# and .35#, the minnesota .39** and .35#, and the Bennett -.04 and .02 with all trade courses. Trade applied physics shows roughly the same pattern as trade courses as a whole. Trade mathematics is surprising in that the arithmetic tests show no significant correlation while the Minnesota shows .30# and .50** and the Bennett shows -.45** and -.22. Trade mechanical drawing had only two tests that had sufficient numbers to run correlations, the Otis Q-S and the Minnesota, and neither of these came even close to having significant results. Since the numbers in the trade groups are even smaller than in the technical, any results are less meaningful, even though the use of the null hypothesis in the testing of the significance of the obtained correlation balances some of this. The need for further study is especially apparent in the trade course area.

Table X shows the inter-correlations between the various tests of the battery. The intention here was to see to what extent the various elements of the test battery were dependent on common factors. The product-moment correlations were used in this table. The

TABLE X

INTERCORRELATIONS OF THE VARIOUS TESTS

Tests	Number	r
Otis Q-S versus		
Minn. P.F. Bd.	179	.17 #
Bennett Mech.	137	.33 **
Purdue Indust.	41	.18
Otis Arith.	66	.71 **
Thurstone Arith.	41	.47 **
Foust-Schorling	111	.57 **
Iowa Algebra	97	.66 **
Minn. P. F. Bd. versus		
Bennett Mech.	137	.23 **
Purdue Indust.	41	.21
Otis Arith.	66	.03
Thurstone Arith.	41	.24
Foust-Schorling	111	.08
Iowa Algebra	97	.12
Bennett Mech. versus		
Purdue Indust.	39	.05
Thurstone Arith.	39	.09
Foust-Schorling	111	.44 **
Iowa Algebra	97	.23 #
Purdue Indust. versus		
Thurstone Arith.	41	.65 **
Foust-Schorling versus		
Iowa Algebra	97	.69 **

** Significant at the .01 level

Significant at the .05 level

highest correlation was between the Otis Q-S and the Otis Arithmetic (.71**) and as the Otis Arithmetic is test 5 of the Otis Group Intelligence Scale, advanced (an earlier test by Otis) this seems logical as a good percent of the items on the Q-S are arithmetic items of a similar type. The Otis Q-S in general correlates better with the mathematics and arithmetic tests than with the mechanical and spatial tests. The actual correlations show .17# with the Minnesota, .33** with the Bennett, .71** with the Otis Arithmetic, .47** with the Thurstone Arithmetic, .57** with the Foust-Schorling, and .66** with the Iowa Algebra. The Foust-Schorling and the Iowa Algebra show an intercorrelation of .69**. The Purdue Industrial and the Thurstone Arithmetic show .65**. The Bennett Mechanical shows .44** with the Foust-Schorling but only .23# with the Iowa Algebra. With the exception of .23** with the Bennett and .17# with the Otis Q-S the Minnesota shows no significant correlation with the others. This might possibly indicate that it was the most independent item in the test battery.

If we try to match the test intercorrelations against the prediction of the tests with the various

criteria no clear pattern presents itself. Future research might help clarify this (or some other statistical method) but at present no valid conclusions could be drawn.

CHAPTER V

CONCLUSIONS

The justification for studying a particular group of individuals is the hope that the knowledge gained will assist in understanding a similar group in the future. If we try to delude ourselves with a statement that our only interest is in the group under examination we become hopelessly academic in the worst sense of the word. Not that a pilot study such as this should expect to reach a level where generalizations could be formed that would apply to future applicants to this technical institute; but it should be so aimed that it could serve as the first rung of a ladder rather than be just an isolated chunk of wood.

The validity of extending generalizations derived from a study of any given group depends on the representativeness of the sample. The conclusions drawn from this sample could not be applied generally to either the general population, trade schools or other technical institutes as this is not a random sample of any of those groups. The question as to whether another group of students at this school could be predicted from this sample could only be determined by

studying several successive classes. In other words, the representativeness of this group cannot be proved without further research. For one thing this is largely a veteran group so that prediction of success for a group just out of high school might be a different matter. One question might be whether a group of students just out of school might not make a significantly higher score on a mathematics test than those who had been out of school for a few years. This writer's guess would be that the scores would be higher, but it might be that it would be an even, over-all increase that would not appreciably affect the correlations with the criterion. Here again future study holds the answer.

The ability of a given test to predict success in a given subject is of interest from the point of view of further research more than for any other single reason. This ability to predict in a given subject would be of little use to the admissions committee unless it were possible to predict in all subjects in a course and then by weighting the tests arrive at a pattern that would be of assistance. The ability to predict a subject or two out of a course is an indication that we are perhaps on the right road but it is

not sufficient to base any judgment for potential success of future students. This ability to predict in one subject and not in another should with study have certain implications as to additions necessary to the test battery before adequate prognostications can be accomplished.

One distinct limitation of this study is that the largest group has only one hundred seventy-nine students and when we reach the individual subjects the numbers are in the realm of rather small sample theory. As a pilot study, however, this writer feels that the correlations run on these small groups are well worth the labor involved.

If the next study at this school gave similar results the obtained correlations could be considered quite promising. Considering that the criterion was school success in terms of grades the results correspond quite well with previous research. No attempt was made to see whether a given test predicted any particular "aptitude." The problem was solely the question of whether success in school could be predicted with the criterion of marks and a battery of group tests. Any other criterion would be primarily theoretical as the success of future students would be based on their

school marks. The fact that the only significant correlation found with the technical English was with the Otis Q-S might be an indication that in general the battery was reasonably well aimed at a technical curriculum.

The fact that a group selected for entrance to a technical institute is in all probability a rather homogeneous sample makes the fact that several correlations above .40 were found a rather encouraging factor.

The largest unanswered question is why a test predicts at one division point and not at the other. At present no answer that is more than a guess could be put forth. It certainly is one problem area that should be explored thoroughly.

CHAPTER VI

SUGGESTIONS FOR FURTHER RESEARCH

The first recommendation would be that in further research the test battery be both varied and expanded. In the first instance it might well be profitable to experiment with other measures of spatial relations, such as the Spatial Relations part of the Chicago Primary Mental Abilities test or Ruch's Survey of Space Relations as examples. A more difficult mechanical test such as form BB of the Bennett might be worth the trial, or possibly some other type such as the Purdue Mechanical Adaptability test might give better results. Some other measure of general mental ability should be tried, even though the possibility exists that specialized ability could be the answer. The Otis Q-S may correlate better with a type of ability not essential in a school of this type. The civilian edition of the Army General Classification Test might be worth a trial. The Chicago Primary Mental Abilities is probably too long to be used as an admissions test in its present form, unless experimentation with the students indicated that certain sections were useful. The Otis Arithmetic test could probably be discarded from further research

without serious loss as no correlations were found that were significant at the one percent level. Both the Foust-Schorling and the Iowa Algebra would seem from present results to be worth inclusion in any future test battery. Other tests of a similar type and a commensurate difficulty level might well be experimented with however to see if improvement in prediction could be achieved with a different test. The Purdue Industrial test might be improved in prediction if both forms were given, or if a similar test of greater difficulty were discovered. If the latter, it might be interesting to try it on the technical group also. The Thurstone Arithmetic test might also be usable for the technical group as the mean for the trade group was rather low. The element in common in both of these last-mentioned tests seems from inspection to be that of problem solving. If other tests involving arithmetic problem solving of a suitable difficulty level cannot be obtained commercially it might be worth the effort to develop one especially for this school. Empirically at least problem solving would seem to be inherent in some of these showing the best obtained correlations. The Foust-Schorling seems to have some of this also but in

addition relies on some knowledge of algebra fundamentals.

In further research it might return interesting results if the good versus the poor students were matched against the individual test items rather than against the total test score. Machine calculation would be essential if this were to be done economically from either a time or financial point of view.

Another technique that should certainly be tried in the future would be that of multiple correlation. It could be that some other weighting (once adequate prediction in individual subjects was obtained) might offer the best chances for selection of the students with the best potentiality for success. Only future research holds the answer to that. The present study gives no indication as to how much, if any, we could increase group prediction by the combination of tests that is inherent in a multiple correlation technique.

It might be worth while to investigate other areas in any future study. The immediate ones in mind are those of interest and personality. Whether such a test prior to entrance would give valid results has some elements of doubt but should be worth the experimental effort. The element of personality that would

seem to be of value is whether we could gain any indication as to whether a student would or could make use of the potentiality shown in the other tests. Working with the actual data it is always interesting to see the cases that are way out of expectation, both high and low, and to speculate on the reason therefore. In a way this could be termed school-room personality. The way that this differs from school-room ability is obvious to all the better teachers. The possibility exists that the ability to get along with the teacher indicates a similar ability to get along with the foremen and superintendents in industry. The measurement of interest might result in a slight overall increase in the ability to predict success. It might weed out a few persons who, due to inadequate occupational information, were tackling a program that was entirely out of line with their basic pattern. Interest ideally would be connected with the drive for success but to what extent any present test would measure this aspect is at the least questionable.

Thus the question arises as to what extent present tests are capable of adequate group prediction of school success, individual prediction being obviously out of the realm of statistical practicality. The

element of error for selection of successful students is so large in this present experiment, and in most previous ones, that on the basis of this single study no concrete recommendations could be safely made to an admissions committee, except that the road seemed promising for further travel. The problem has only been scratched but the writer feels that continued work would be most profitable in returns both to the school and to the prospective students. The ideal conclusion would be when the results had wide implications for the guidance of youth in general.

The best result that should be expected from a pilot study could well be compared to an artillery battery that fires the first few rounds to bracket the target before it fires for effect. This study compares to the first round fired in that advance calculations were made but the report of the forward observer must be given as to where it landed in relation to the target before we can correct out aim. Fortunately this first round landed where its relation to the target could be seen. The next step in a gun battery is to adjust the calculations and fire another round. Here the calculations are not so easily adjusted but we do the best we can. The next step then is to "fire another round" and

see if we bracket the target. Only when this is done can we tell whether to fire for effect or to adjust and try again. The encouraging factor is that this first shot was within sight of the target and not over the next hill and out of sight.

see if we bracket the target. Only when this is done can we tell whether to fire for effect or to adjust and try again. The encouraging factor is that this first shot was within sight of the target and not over the next hill and out of sight.

APPENDIX A

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APPENDIX B

TESTS ADMINISTERED

1. Otis Quick-Scoring Mental Ability Test, Gamma Test, Form Am, by Arthur S. Otis, published by World Book Company.

2. Revised Minnesota Paper Form Board, Series Ma, by R. Likert and W. H. Quasha, published by the Psychological Corporation.

3. Bennett Test of Mechanical Comprehension, Form AA, by George K. Bennett, published by the Psychological Corporation.

4. Foust-Schorling Test of Functional Thinking in Mathematics, Form A, by J. W. Foust and R. Schorling, published by the World Book Company.

5. Iowa Algebra Aptitude Test, Revised Edition, by H. A. Greene and A. H. Piper, published by the Bureau of Educational Research and Service State University of Iowa.

6. Purdue Industrial Training Classification Test, Form A, by C. H. Lawshe and A. C. Moutoux, published by the Science Research Associates.

7. Otis Arithmetic Reasoning Test, Form A (Test 5 of Otis Group Intelligence Scale, Advanced Examina-

tion) by A. S. Otis, published by the World Book Company.

8. Arithmetic Test, Thurstone Vocational Guidance Tests, by L. L. Thurstone, published by the World Book Company.

APPENDIX C

COURSES OFFERED AT WXYZ TECHNICAL INSTITUTE

TECHNICAL COURSES

	First Term	Second Term	Unit Weights
Machine Construction and Tool Design			
Mathematics	x	x	3
Mechanical Drawing	x	x	2
Applied Physics	x	x	4
Motor Laboratory	x	x	2
Electricity	x	x	4
Welding	x	x	1
Foundry	x	x	1
Patternmaking	x		1
Machine Work		x	1
English	x	x	2
Electrical Construction			
Mathematics	x	x	3
Mechanical Drawing	x	x	2
Applied Physics	x	x	4
Electricity	x	x	4
Motor Laboratory	x	x	2
Welding	x		1
Patternmaking	x		1
Electric-wiring		x	1
Machine Work	x	x	1
Foundry		x	1
English	x	x	2
Steam and Diesel Engineering			
Mathematics	x	x	3
Mechanical Drawing	x	x	2
Applied Physics	x	x	4
Electricity	x	x	4
Motor Laboratory	x	x	2
Patternmaking		x	1
Machine Work	x		1
Foundry	x	x	1
Welding	x	x	1
English	x	x	2

Architectural Construction	First Term	Second Term	Unit Weights
Mathematics	x	x	3
Architectural Drawing	x	x	4
Applied Physics	x	x	4
Building Methods	x	x	2
Carpentry	x	x	1
Building Materials Laboratory	x	x	2
English	x	x	2
Aircraft Maintenance Engineering			
Mathematics	x	x	3
Mechanical Drawing	x	x	2
Applied Physics	x	x	4
Electricity	x	x	4
Welding	x	x	2
Aircraft Shop Technique		x	2
Machine Work	x		2
Pattern Shop	x	x	1
Civil Aeronautics Rules		x	3
Industrial Electronics			
Mathematics	x	x	3
Mechanical Drawing	x	x	2
Applied Physics	x	x	4
Electricity	x	x	4
Motor Laboratory	x	x	3
Radio Shop Technique	x		1
Electronics	x	x	5

INTENSIVE SHOP COURSES

Pattern-Making and Machine Design	First Term	Second Term	Unit Weights
Mathematics	x	x	3
Mechanical Drawing	x	x	3
Applied Physics	x	x	5
Pattern-Making	x	x	6

	First Term	Second Term	Unit Weights
Machine-Work and Tool Making			
Mathematics	x	x	3
Mechanical Drawing	x	x	3
Applied Physics	x	x	5
Machine Work	x	x	6
Building Construction			
Mathematics	x	x	3
Architectural Drawing	x	x	3
Applied Physics	x	x	5
Carpentry	x	x	4
Building Materials Laboratory	x	x	3

The courses listed above include only the first year subjects as the second year was not a part of this study.

APPENDIX D

DETAILS OF THE MARKING SYSTEM AT WXYZ TECHNICAL INSTITUTE

The plan consists of a unit value for each subject, a weight for each grade, the credit earned in each subject, a half-yearly "index", honor grades, passing grades, and minimum requirements.

Unit values for each subject are given in the tables for each course (see Appendix C).

The weight given to each grade is as follows: A equals 4, B+ equals 3.5, B equals 3, C+ equals 2.5, C equals 2, P equals 1, and D equals zero.

Credit earned in each subject is determined by multiplying the unit value of the subject by the weight of the grade received for that subject.

The grade "index" equals the sum of the credits earned divided by the sum of the unit values.

Honor rating is given students whose index is 3.50 or above. Promotion requires an index of 1.50 or better. The final index for the second half-year, either first or second year, must not be below 1.50.

Graduation requires not only a passing index, but each student must also satisfy the faculty with regard

to his attendance and character, and he must have shown a sincere desire to attend all classes and to meet all requirements of every subject in his course.